Melampus bidentatus survives harsh winter temperatures by allowing ice to form in its body fluids. This freezing tolerance is a seasonal mechanism that is present from late fall to mid-spring. The mean lethal temperature of the snail ranges from -13.0° C in December to -5.5° C in July, while the corresponding supercooling point of the hemolymph ranges from -7.4°C to -11.5°C. The winter hemolymph contains ice nucleating agents that promote extracellular ice fromation at high temperatures, preventing excessive supercooling and lethal intracellular ice. When heated at 100° C for 5 minutes, the winter hemolymph lost all nucleating activity. Dialysis for 24 hours caused no change in supercooling temperature, and indicated that the molecular weight of the nucleator was greater than 12,000 to 14,000. Treatment with a non-specific protease decreased the supercooling point, but the change was not significant. A 1% solution of hemolymph and distilled water raised the supercooling point of the water significantly. These data indicated that an ice nucleating agent is produced in the hemolymph in the winter and degraded in the spring, and is probably proteinaceous.

FUNCTIONAL IMPORTANCE OF THE PALLIAL EYE OF *CERITHIDEA SCALARIFORMIS*. Thomas N. Rogge, Department of Biological Sciences, University of Southern Mississippi, Hattiesburg.

A preliminary study was done to investigate the differences between the pallial and cerebral eyes of the marine mesogastropod *Cerithidea scalariformis*. Of particular interest was the function of the pallial eye, which fits into the siphonal notch of the shell aperture and is visible through a transparent spot in the operculum. *C. scalariformis* is considered amphibious, spending a great amount of time suspended from marsh grasses by mucous threads. When feeding, the snail's head is buried in the bottom detritus, leaving only the pallial eye unobstructed. Histologically, the different eyes reflect behavioural differences in the snail. Using simple light/dark preference tests, it was found that snails with pallial vision (cerebral eyes removed) behaved similarly to snails with complete vision (all eyes intact), whereas snails with cerebral vision (pallial eyes removed) behaved oppositely to snails with complete vision. From experimental results and field observations, I suggest that the pallial eye has twofold importance: orienting and directing the snails movements and to "watch" for possible predatory dangers both while feeding and suspended from grasses. Both in the field and laboratory, the snail will dislodge itself and fall from its suspended perch or withdraw into its shell while feeding if passed closely by. It is possible that this is a reaction to moving shadows of potential predators.

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EXPLORATION FOR COMMERICAL QUANTITIES AND MARKETS FOR BLOOD ARKS. Arnold G. Eversole, Department of Aquaculture, Fisheries and Wildlife, Clemson University , Clemson, **WIIIIam D. Anderson** and **Will H. Lacey**, Office of Fisheries Management, South Carolina Wildlife and Marine Resources Center, Charleston, South Carolina.

Eighteen hydraulic escalator cruises were made in 1983 and 1984 to assess the potential for commercial exploitation of blood arks along the coast of South Carolina. Commercial concentrations of *Noetia ponderosa* and/or *Anadara brasiliana* were located in 7 of 27 areas sampled. *N. ponderosa*, the most abundant species, was found in high salinity waters behind coastal barrier islands with populations of *Mercenaria mercenaria*, *Chione cancellata* and *A. ovalis*. The second most abundant ark, *A. brasiliana*, was found frequently 1/4-1/2 nautical miles offshore of barrier islands in sandy substrata, sympatrically with *Polinices duplicatus*. *A. ovalis*, the true blood ark, was third in abundance and usually found with *N. ponderosa*. *A. transversa* was rarely caught and never in commerical concentrations. *N. ponderosa* was the largest ark and had the heaviest shell of the species assessed. *A. ovalis* had the smallest mean shell length and the lowest meat yield (meats per pound). Ark meats contained considerable water (83%) and protein (68% on a dry weight basis).

Hydraulic escalator harvesters with Maryland-type heads were evaluated in offshore and estuarine waters for harvesting arks in subtidal waters. This gear proved most effective in estuarine areas at depths less than 8.0 meters.

Questionnaires containing valves of the three most abundant species were sent to seafood dealers in 10 countries including the United States. Responses to questionnaires indicated that 50% of the dealers were familiar with these species and 80% reported a similar species in their market. Other responses to questions about product marketability and price indicated little potential for exporting these species to foreign markets. This may be due in part to the fact that *A. granosa* and *A. broughtonni* are abundant in the Far East. Responses from domestic seafood dealers also indicated there was no viable market for blood arks at this time.

THE EVOLUTION OF LIGAMENT SYSTEMS IN THE BIVALVIA. T. R. Waller, National Museum Of Natural History, Smithsonian Institution, Washington, D.C.

Ligament systems (arrays of fibrous and nonfibrous ligaments and their supports) were surveyed throughout the Bivalvia with particular attention to structure, ontogeny, paleontology, and taxonomic distribution. New observations indicate that the primary ligament system was opisthodetic but that the inner ligament layer contained aragonitic granules, not fibers as in modern fibrous ligament. A vestige of such a system remains in modern Nuculacea.

Primitive opisthodetic ligament systems, termed *simple arched or planar systems*, rest on the unmodified inner surface of the shell without nymphae and may or may not be arched depending on the relative thickness of fibrous and nonfibrous ligaments. Among modern bivalves such systems are limited to the Nuculanacea (where they are typically developed in the Malletiidae) and the Nucinellidae in the Solemyoida.

Other ligament systems can be derived from simple

arched or planar systems by means of two morphological events which occurred independently, producing two major clades. One event was the development of nymphae, ridges formed from the inner surface of the shell which serve to enhance arching. Nymph-bearing systems, to which the term *parivincular* is restricted, are exclusively opisthodetic and occur in the Solemyidae and throughout the subclasses Anomalodesmata, Paleoheterodonta, and Heterodonta. The other event was the development of *pseudonymph*ae, which consist of modified ostracum and serve as fillers between ligaments and shell. Pseudonymph-bearing systems, termed herein *planivincular*, are exclusively opisthodetic and are taxonomically restricted to the subclass Isofilibranchia. Planivincular systems are also characterized by discontinuous ontogeny of fibrous ligament, the initial portion being a tiny fibrous resilium. In *Dacrydium*, only this early part remains, the remainder of the ligament system being truncated by neoteny. Multivincular and duplivincular systems can be derived from planivincular systems by similar truncation and by the reestablishment of adult ligament systems through repetition of either fibrous or nonfibrous ligament. The Pectinacean ligament system, with its unique centrally nonfibrous resilium, would appear to be derived from a duplivincular system.

The parivincular clade originated by middle Ordovician time in forms such as *Ctenodonta nasuta* (Hall). The planivincular clade likely originated from the Protobranchia even earlier.

SHELL MICROSTRUCTURAL VARIATION REFLECTS HABITAT INFLUENCE IN *GEUKENSIA DEMISSA GRANOSISSIMA* (BIVALVIA: MYTILIDAE). Antonieto Tan Tiu, University of Southern Mississippi, Hattiesburg, Mississippi.

Live specimens and freshly shucked shells of the Atlantic ribbed mussel, *Geukensia demissa granosissima*, transplanted to a continually submerged habitat (Winter 1985, Ocean Springs, Mississippi) showed an internal shell growth layer different from that of mussels of higher *Spartina alterniflora* Loiseleur-Deslongchamps salt marsh. The high salt marsh was alternately exposed to air and submerged in water (about 50% of total experimental period), while submerged habitat was continuously submerged in water. Shell lengths significantly decreased in emerged mussels (high marsh) and increased in submerged mussels (submerged habitat). Scanning electron microscopy observation of the internal shell microstructure inside and outside the pallial line of both anterior and posterior regions of initially collected (baseline) and caged mussels (live and freshly shucked shells) revealed that (1) Inside the pallial line, the nacreous layer was predominantly eroded in all mussels; a homogeneous-like microstructure composed of variously shaped and sized particles occurred in all mussels but submerged. (2) Outside the pallial line, growing and mature tablets with smooth surfaces were observed in both baseline and submerged mussels but not emerged mussels. Few emerged mussels had elevated borders of continuous ridges, beads or granules that surround partially or completely one or more tablets. These circumferential ridges may be due to shell dissolution rather than shell formation. In conclusion, distinct differences in internal shell microstructure occurs in mussels maintained between different habitat within a very small area. Submerged regions, at least in the winter season of the Mississippi Gulf Coast, may offer some buffering capacity to climatic variation and thus increase the ability of *G. d. demissa* to deposit shell material or deter shell dissolution.

INTENSE PREDATION BY CRABS ON MANGROVE LITTORINIDS. David G. Reid, Department of Invertebrate Zoology (Mollusks), National Museum of Natural History, Smithsonian Institution, Washington, D.C.

A taxonomic revision of the "*Littorina scabra*" group in the Indo-Pacific using characters of the shell and anatomy, has defined 17 species, which are placed in the genus *Littoraria*. Five of these species occurred at a study site on Magnetic Island, Queenland, where they were zoned at characteristic heights above the water level on *Avicennia* and *Rhizophora* trees.

From field observations and laboratory experiments, the major predators of post-larval snails were concluded to be grapsid crabs of the genus *Metopograpsus*, and the portunid *Thalamita crenata*. The grapsids were small, tree-climbing crabs with unspecialized chelae, capable of crushing small or thin-shelled snails. The portunid was a large species with dimorphic chelae, able to crush even the largest *Littoraria* species, but could only reach prey close to the water surface. From exclusion cage experiments in the field using *L. filosa*, it was estimated that crabs caused 79% of the mortality of snails in the size range 7 to 12 mm.

Repaired V-shaped breakages on the shell preserve a record of unsuccessful predation attempts by crabs during the life of a snail. Frequencies of repaired breakages in the *Littoraria* species were very high (means of 0.66 to 3.48 repairs per shell). From the known growth rates of the species, rates of injury were calculated, and found to be highest at small shell sizes (< 5 mm for most species). The size at which the rate of injury was highest corresponded to that at which snails just achieved immunity to the majority of *Metopograpsus*.

The *Littoraria* species zoned at lower levels on the mangrove trees had thicker shells, which can be explained as an adaptation to the increased severity of crushing predation nearer the water level.

CONTRIBUTIONS OF ALPHEUS HYATT TO MALACOLOGY. Ralph W. Dexter, Kent State University, Kent, Ohio.

Alpheus Hyatt (1838-1902) was trained by Louis Agassiz, and served as Honorary Curator of Fossil Cephalopods at the Museum of Comparative Zoology for life (1865-1902). He was also part-time Curator of Conchology (1863-67) and Curator of Paleontology (1867-70) at the Boston Society of Natural History, and Curator of Lower Invertebrates at the Peabody Academy of Science, Salem, Mass., before returning to the Boston Society of Natural History (1870) as Museum Custodian (i.e. Curator) for the remainder of his career. He founded the Teachers School of Science and the Annisquam Seaside Laboratory (which became the